“5th Generation” High Current Solid Target Irradiation System

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Introduction

A new high current (up to 50 kW) solid target irradiation system is being built. While retaining the same beam power capability of the previous target generation, the system is a totally new design with many improvements, simplified constriction, more reliable operation and a novel approach to target handling, beam collimation and beam diagnostic.

Unlike the previous, three-part soldered target, the new target is fabricated from a single piece of metal.

Material and Methods

The target (or rather the target-material holder) is a single metal plate (usually copper or silver) incorporating the seals and the cooling channels (FIG. 1). The target is placed in the beam at 7°. Depending on target material and coolant flow the target can handle beam powers up to 50 kW (FIG. 2).

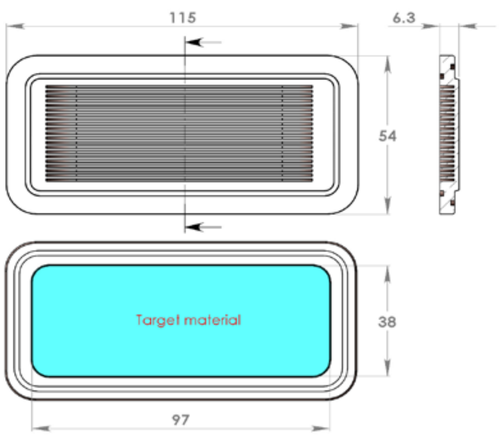

FIGURE 1. Target view and section

General view of the target station is presented in FIG. 2.

The target station consists of 5 main modules:

1. Insulated target chamber
2. Landing terminal
3. Manipulator
4. Collimator and mask box
5. Vacuum system

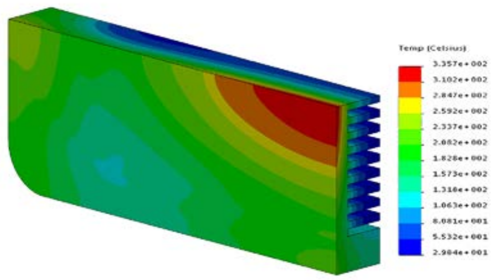

FIGURE 2. Thermal modelling: 50 kW beam (42.5 kW on target, 7.5 kW on collimator), 40 L/min water flow

Target transfer (utilizing a special shuttle) is pneumatic. Part of the transfer pipe is shown above the target station.

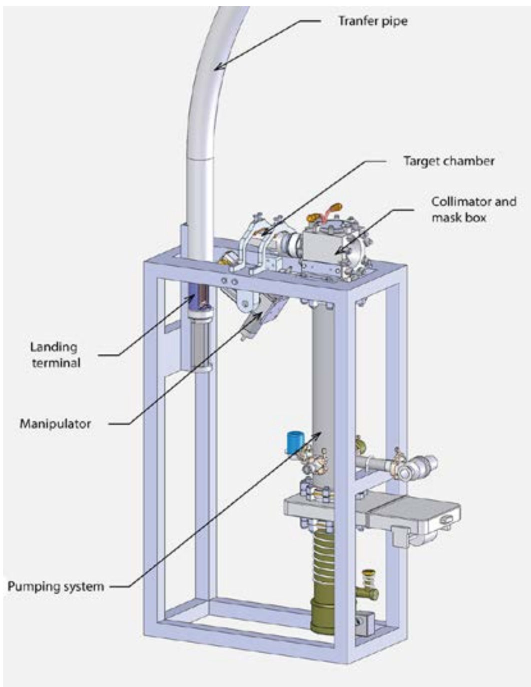

FIGURE 2. Target station modules

Except the target o-rings (a part of each target) there are no elastomer seals in the system; all is of soldered/welded construction and metal seals.

Sectional view (FIG. 3.) shows that target in place in the chamber. The target and the chamber are electrically insulated from the rest of the sys-

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tem, thus forming a Faraday cup for accurate current measurement.

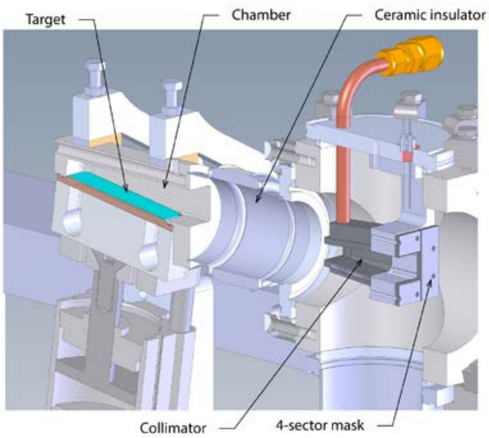

FIGURE 3. Sectional view of the target chamber

The collimator is formed of a two part silver casting. It is designed to handle up to 10 kW of beam power. Four-sector silver mask in front of the collimator allows precise beam cantering.
The collimator parts were cast using 3D printed wax patterns. This allowed to create a complex pattern of cooling channels that are difficult to produce by machining (FIG. 4.)

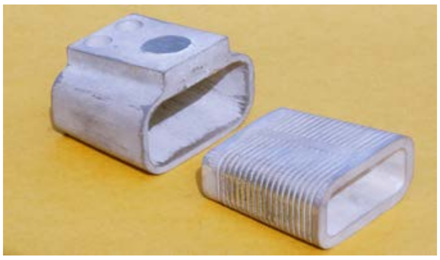

FIGURE 4. Collimator parts after casting

All the actions of target shuttle landing and the target placing are performed by three air cylinders. All three are fitted with Vespel SP22 (Du Pond) seals.
Unlike previous systems that used mechanical grabbers to manipulate the target, low vacuum is employed to hold the target during removal from the shuttle and placing in the irradiation chamber. This greatly simplifies the operation and is more reliable.
The pneumatic transfer system is using two vacuum producer to transfer the target shuttle between the target station and the hotcell. Both landing terminals in the target station and hotcell, as well as the transfer line itself, are under negative pressure preventing any spread of contamination.

The hotcell landing terminal incorporates a fully automatic target-material dissolution system. After landing, the target is removed from the shuttle and the active face pressed against a reaction vessel where the dissolution takes place (FIG. 5.)
All the functions of target transfer, placing and manipulations are controlled by a simple PLC (FMD88-10 PLC, Triangle Research)

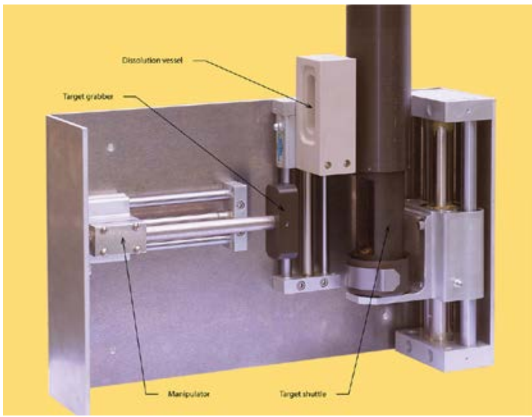

FIGURE 5. Hotcell landing terminal and target-material dissolution unit

Results and Conclusion

While intended mostly for cladding with metallic target materials, a special version of the target was designed to handle salts or oxides that can be fused and retained in grooves on the target face (FIG. 6.) Despite the poor thermal conductivity of most of those materials, this target can handle high beam currents.

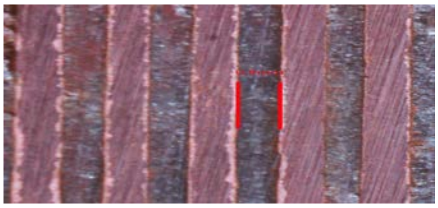

FIGURE 6. Grooved target face with rubidium chloride fill.

FIGURE 7 shows a thermal modelling of the central 10×25 mm segment of the target (highest heat flux region under a Gaussian beam). Copper target with rubidium chloride fused in 0.8 mm wide and 1.7 mm deep grooves and spaced by 0.5 mm (60% coverage). Beam of 70 MeV energy and 400 µA intensity is collimated 20 % (320 µA on target). Cooling-water flow is set to 25 l/min.

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Cladding the target face with a thin metallic layer can help containing the target material. This process is currently under development.

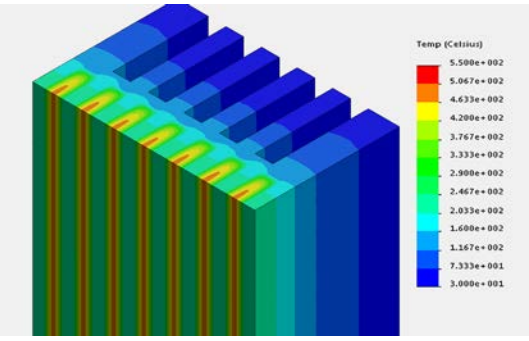

FIGURE 7. Grooved target thermal modelling

Most aspects of the system operation and constriction were successfully used in the previous “generations” of targets in the last 30 years. The new system will provide improved performance with a simpler and more reliable design, lower maintenance and lower consumables cost.
FIGURE 8 shows the “4th generation” system and target (2005). Dozens variants of this design are in use all over the word.

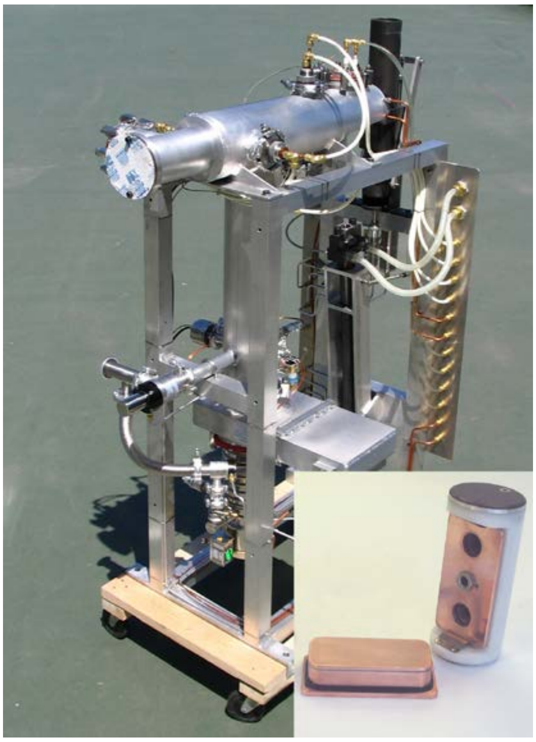

FIGURE 8. “4th generation” target station (2005). Target and shuttle (insert)

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Acknowledgements

In part, the present work has been financed by the National Research Council, Canada, IRAP grant # 811102/2013.